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Research Paper

An Inter-District Analysis of Instability and Sustainability for Major Crops in Haryana

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ABSTRACT

Increased volatility in farm production and sustainability of crops is a growing concern issue, and state-level analysis cannot reflect a complete scenario of volatile production behavior of different crops so district level study is taken up in this article. The study has estimated instability and sustainability in three major crops in the last three decades at district levels in Haryana. It was observed that Gram crop area is declining in every district at a very rapid pace. Cotton and mustard have seen facing severe ups and downs throughout the study period. To meet the demand of food and nutritional security, sustainable production is required and selected crops yield sustainability. Udemand of food and nutritional security, sustainable production is required, and selected crops yield sustainability was estimated using several sustainability indices at the district level.

Highlights

- District-level agricultural planning and determining agricultural operation at the district level to meet rising food and nutritional security demand are essential.

Keywords: CAGR, instability, sustainability

Studies related to growth and instability are mostly focussed on the aggregate level, and policies are formed on the basis of these aggregate-level studies. Irregular growth and increased variability have always been the topics of intensive debate as agricultural products affects farmer's income and decision to invest in farming. A deeper understanding of the existence and extent of risk at the disaggregated level involves establishing a more effective risk management mechanism. Aggregate level studies can not provide a complete picture of growth and variability existing at disaggregated level or district level. Gram, cotton, and mustard have always been essential crops, and in Haryana, all these were grown on a huge area in the past. In the year 1990, an area under gram was above 300 ('000 ha) and has declined below 50 ('000 ha) in recent years. As cotton and mustard still have their place in terms of grown acreage, gram is losing its area very rapidly despite the yield growth. Several factors are responsible for increased variability, and a thorough study is required at a disaggregate level.

Cotton is one of the prime important crop in fiber crops. Haryana comes in India's top five cotton cotton-producing states according to the cotton production data of year 2019-20. Haryana produced 24lakh bales (2019-20) of cotton and contributed almost 7 percent of the total country's production. The growth and stability of cotton crop have always been very irregular due to various factors like weather conditions and insect pest attacks, etc.

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Gram is known for its replacement of meat in a vegetarian diet due to its higher protein content. Gram has several health benefits with reducing the risk of several diseases and a very rich source of vitamins and minerals. Other rabi crops are substituting the area of a gram in Haryana despite the increased productivity. Mustard is a high oil bearing seed and a common edible vegetable oil having several medicinal properties like; prevents cancers formation in the body and reduces body temperature, antifungal, and antibacterial property. Mustard is accounting almost 25 percent of total oilseed production and is regarded as the most important oilseed crop, an important source of fatty acids. We are importing a large amount of vegetable oil and producing a large quantity of wheat. Both are rabi crops, so to fill this gap, encouragement of mustard is necessary as wheat is replacing the mustard area. Various studies related to stability and growth of gram, cotton, and mustard (Rani 2019; Kumar 2015; Kumar *et al.* 2019; Monika *et al.* 2018; Vishwajith *et al.* 2019) have been done in the past, but all these are aggregate-level studies. To meet the challenge of demand of food and nutritional security, sustainable production is required. So to address the gap adequately the measure of sustainability at the district level will be very helpful for a specific purpose. As a rising consensus has been reached on the need for district-level agricultural planning, finding the level of agricultural activity at the district level would be of interest. Since there has been a developing agreement about the need for locale level farming arranging, it would be interesting to gauge the degree of farming movement at the region level. A district-level analysis would be helpful in formulating district-specific agricultural policies. The seriousness of emerging acute regional imbalance has not yet earned the attention it needs. The earnestness of arising intense local uneven characters has not yet procured the consideration it needs. Tstudy's primary objective is to aim insight into the magnitude of efforts required in Haryana to achieve balanced agricultural development.

MATERIALS AND METHODS

The study is based on data collected from various published sources for the period 1980-2018. The major chickpea, cotton, and mustard crop growing districts have been taken under consideration, and data on the area, production, and yield of selected crops have been utilized. For chickpea Mahendragarh, Hisar, Sirsa and Bhiwani districts, for cotton Bhiwani, Jind, Hisar, Sirsa, and Fatehabad, and mustard Mahendragarh, Rewari, Bhiwani, Hisar, and Sirsa were selected. These districts shared almost 90 percent of total state production for their respective selected crop. To measure the variability or instability factor in the collated data, Coefficient of Variation (CV) and coefficient of variation around trend (CV_t) have been used. The coefficient of variation is the statistical measure of the dispersion of data points in a series around the mean. It is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from each other and is given by Mishra and Homa (2019):

$$CV = \frac{\sigma}{\bar{X}} \times 100$$

Where, σ = Standard Deviation, $\bar{X} = Mean$.

Coefficient of variation around mean or Index given by Cuddy and Della (1978) and used by Larson *et al.* (2004):

$$CV_t = (CV) \times \sqrt{1 - R^2}$$

where, R^2 = coefficient of determination, CV_t = CV around trend. The annual compound growth rates for area, production and yield were estimated using the following model:

$$Y = ab^t$$

where, Y = harvest area / production/ yield of selected crops; a = constant, $b = (1 + r)$, r = compound growth rate, t = time in years.

The some of the measures found in literature used to measure the sustainability of identified crops our study are as under. The study assumes here that sustainability implies persistence and the capacity of a state to produce crops continuously for a long time. Thus, under the present context, persistency in productivity of a crop across a long period of time implies sustainability.

Pal and Sahu (2007): $SI = \frac{S_i}{\bar{y}_i} \frac{1}{S_{i\max}}$, where $\bar{y}_i$ is the

average yield of the i^{th} treatment, S_i is the standard deviation of i^{th} treatment over the years and $S_{i\ max}$ is maximum standard deviation among all the treatment; lower the value of the sustainability index higher is the sustainability.

According index given by ICARDA (1994), $y_{ij} = a + b_i \bar{y}_j$ $y_{ij} = a + b_i \bar{y}_j$, where $\bar{y}_j$ is the mean of all the treatments in the j^{th} year and b_i is the regression coefficient for i^{th} treatment, y_{ij} is the value of yield with respect to i^{th} treatment and j^{th} year and SI is $|1/b_i|$.

Vishwajith *et al.* (2018) have used standard error of the estimate from the regression equation $y_{ij} = a + b_i \bar{y}_j$ in the index given Pal and Sahu instead of using simple standard deviation. $S.I = \frac{SE(b_i)}{\bar{y}_i} \frac{1}{SE(b_{i\max})}$. According to this proposed index, lower the value of the index, higher is the sustainability status of the treatment.

RESULTS AND DISCUSSION

Table 1: Area production and yield CAGR (%) of gram in selected districts (1980-2018)

District	Area	Production	Yield
Mahendergarh	-5.65	-4.96	0.17
Bhiwani	-7.63	-7.61	-0.08
Hisar	-10.09	-9.31	0.57
Sirsa	-10.96	-9.38	1.77

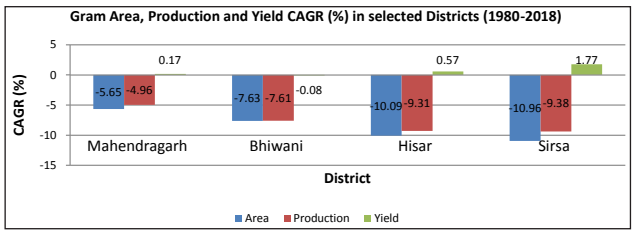

Fig. 1

Table 2: Area production and yield instability (%) of gram in selected districts (1980-2018)

District	CV			CV_t		
	Area	Production	Yield	Area	Production	Yield
Mahendergarh	77.13	72.54	27.2	57.3	59.33	26.99
Bhiwani	66.83	75.81	24.77	37.78	49.34	24.77
Hisar	108.5	124.6	28.01	62.67	86.73	27.41
Sirsa	106	96.09	24.21	56.78	52.73	18.88

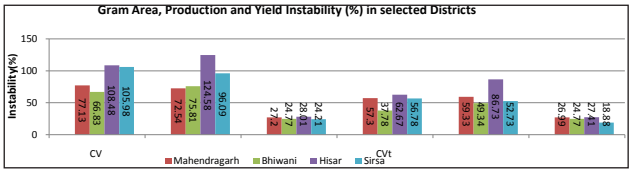

Fig. 2

Growth and instability in production of chickpea

Chickpea is one of the important pulse crops grown on 44.9('000 ha) area in Haryana with production 66.2 ('000 tonnes) in 2018-19. Total pulses area 72 ('000 ha) with production 82.2 ('000 tonnes) in 2018-19 in Haryana. It is mainly cultivated in the western part of the state under rainfed conditions. Chickpea constituted 75.7 percent of total pulses production in the state in 2018-19. The major chickpea growing districts in the state are Bhiwani, Hisar, Mahsendergarh, and Sirsa, sharing 87.8 and 85.2 percent of area and production in 2017-18. All districts had exhibited a negative growth rate in acreage and production during 1980-2018 (Table 1). The strident drop in the acreage of chickpea was observed in Hisar (-10.09%) and Sirsa (-10.96%) districts, and production level also revealed a decline at rate of 9.31 and 9.38 percent per annum in both districts, respectively. However, a sharp decline in growth rate attained higher in acreage compared to a sharp decline in growth rate attained higher in acreage than a sharp decline in growth rate attained higher in acreage than a sharp decline in growth rate attained higher in acreage than the production of chickpea in all districts. This may be caused due to a positive growth rate in chickpea yield except Bhiwani district (-0.08%). The positive growth rate in yield was exhibited due to the adoption of high-yielding cultivars and improved agronomic practices. However, the yield level in the Bhiwani district indicated a negative growth rate over the period as the large area under rainfed conditions, poor soil fertility, severe drought conditions, and shallow temperature in some years.

The plausible reasons for the decline in chickpea production as area shifted towards more remunerative and less risky crops like mustard, wheat, barley due to expanded irrigation facilities and assured procurement arrangement.

The computed value of co-efficient of variations (CV) and co-efficient of variation around trend

(CV_t) for the area, production, and yield of chickpea indicates the relative change in higher variation in all major chickpea growing districts similar results like cuddy and Della(1978). The higher variation in chickpea production was noted during the last four decades (1980-2018) as large areas diverted towards other crops and cultivation is largely extended to rainfed areas. However, the highest variation was recorded in the area (108.48%), production (124.58%), and yield (28.01%)of chickpea in Hisar district as the crop is cultivated on extremely marginal land and largely under rainfed crops. After removing the trend effect, there was a decline in variation for the area, production, and yield of chickpea as it covers all technological advancement etc., effects with years (Mishra *et al.* 2015). The large variation in production was witnessed due to dry land cultivation with low rainfall and poor soil fertility, erratic rainfall, susceptibility to biotic and abiotic stresses, moisture stress, narrow genetic base, etc. The chickpea yield indicated considerable variability because it is grown on residual soil moisture in the post rainy season. The crop often faces moisture stress at planting time and terminal drought due to the absence of protective irrigation or rainfall during crop season.

Table 3: Area production and yield CAGR (%) of cotton in selected districts (1980-2018)

District	Area	Production	Yield
Bhiwani	3.19	4.84	1.60
Jind	1.07	4.07	2.97
Hisar	-2.64	-1.08	1.60
Fatehabad	-1.92	0.98	2.96
Sirsa	-0.11	1.87	1.98

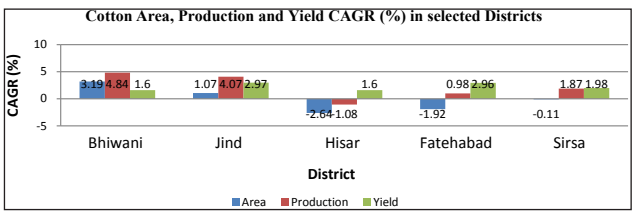

Fig. 3

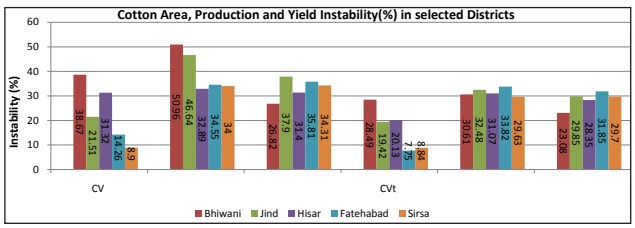

Fig. 4

Table 4: Area production and yield instability (%) of cotton in selected districts (1980-2018)

District	CV			CV_t		
	Area	Production	Yield	Area	Production	Yield
Bhiwani	38.67	50.96	26.82	28.49	30.61	23.08
Jind	21.51	46.64	37.90	19.42	32.48	29.85
Hisar	31.32	32.89	31.4	20.13	31.07	28.35
Fatehabad	14.26	34.55	35.81	7.75	33.82	31.85
Sirsa	8.9	34	34.31	8.84	29.63	29.7

Growth and instability in production of cotton

Cotton is a fiber crop cultivated in *Kharif* season, and its planting started from the end of April to May and picking starts from mid of September to November in the state. It is mainly cultivated in the western part of the state under semi-arid conditions. After introducing Bt-cotton in 2002, at present more than 95 percent area of cotton is cultivated with hybrid seeds of Bt-cotton. The share of Haryana in total area and production of cotton in India is about 5.59 and 7.01 percent, respectively in 2018-19. The cotton is planted on 7.08 lakh ha with a production of 23 lakh bales in 2018-19. The cotton is mainly cultivated in Bhiwani, Jind, Hisar, Sirsa, and Fatehabad districts covering 82.36 percent of the total area with 81.30percent of production.

Based on data of around 40 years (1980-2018), all selected districts had shown negative growth rate in the acreage of cotton except Bhiwani (3.19%) and Jind (1.09%) districts. (Table 3). The traditional cotton growing districts, namely Fatehabad (-1.92%), Hisar (-2.64%), and Sirsa (-0.11%) exhibiteda decline in area coverage as large areas diverted towards paddy owing to expanded irrigation facilities and severe incidence of biotic stresses Mishra *et al.* (2015). However, cotton production in these districts except Hisar (-1.08%) indicated positive growth due to the adoption of Bt-cotton seeds and improved plant protection technologies. The drop in cotton production in the Hisar district was observed as a sharp decline in acreage was captured with a significant increase in yield (1.60%). The positive growth in cotton yield in all significant cotton districts indicated the use of quality and the hybrid seed of cotton, a large share of area under Bt-cotton, balanced use of nutrients, timely planting adoption of improved production, and protection technologies.In recent years, an outbreak of whitefly

and pink bollworm insects again had given setback to cotton cultivation in the state.

The computed value of CV and CV_t for area, production and yield of cotton specified the higher variation in area (38.67%) and production (50.96%) in Bhiwani district and in yield (37.90%) in Jind district Cuddy and Della (1978). The more significant variation in cotton acreage and production in the Bhiwani district was illustrated during nearly last four decades (1980-2018) as large areas diverted from less remunerative crops like pearl millet, cluster bean, *Kharif* pulses towards cotton owing to the introduction of sprinkler irrigation system, subsided and regular electricity supply. The variation in cotton production and yield in all other districts was sizable higher as a cotton crop is susceptible to a large number of insect pests and diseases as it stands a long time in the field, severe drought conditions in some years, and moisture stress in the summer season and fluctuation in market prices.

Table 5: Area, production and yield CAGR (%) of mustard in selected districts (1980-2018)

District	Area	Production	Yield
Mahendergarh	0.62	1.94	1.28
Rewari	0.21	2.24	2.19
Bhiwani	1.95	3.30	1.34
Hisar	-1.02	0.83	1.86
Sirsa	-0.98	0.83	1.99

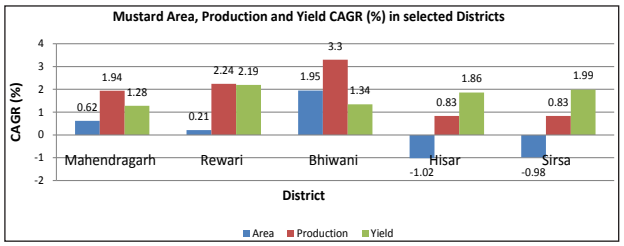

Fig. 5

Table 6: Area, production and yield instability (%) of mustard in selected districts (1980-2018)

District	CV			CVt		
	Area	Production	Yield	Area	Production	Yield
Mahendergarh	11.41	26.52	23.72	10.48	22	21.37
Rewari	6.87	23.88	23.71	6.68	16.75	16.48
Bhiwani	23.01	30.30	19.91	18.34	18.58	16.66
Hisar	25.05	31.96	25.11	22.78	31.43	19.45
Sirsa	27.67	22.65	22.55	26.61	21.8	15.43

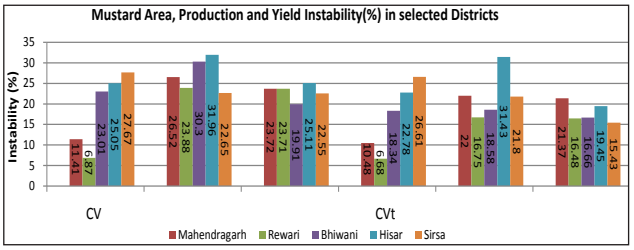

Fig. 6

Growth and instability in production of Mustard

Mustard is one of the pertinent oilseed crops grown in the western part of the state. Haryana state ranked the first position in terms of mustard productivity (2058 kg ha^{-1}) against the national average (1511 kg ha^{-1}) in India. Mustard is cultivated on an area of 609.20 thousand ha in Haryana with the production of 1253.73 thousand tonnes sharing 9.95 and 13.55 percent of total area and production of mustard in the country in 2018-19 Devi *et al.* (2019). It contributed 58.90 percent of the production of total oilseeds in the state. It is primarily cultivated under irrigated conditions in the *rabi* season. The keymustard growing districts in the state are Bhiwani, Hisar, Mahendergarh, Rewari, and Sirsa, sharing around 70 percent and 69.70 percent of area and production in 2017-18. All districts had unveiled a positive growth rate in acreage, production, and yield during the period 1980-2018, while Hisar (-1.02%) and Sirsa (-0.98%) districts exposed a drop in area (Table 5). The plausible reasons for positive growth in mustard production all districts result from continuous increase in area due to its profitability and significant upsurge in yield with high yielding varieties seed and good agricultural practices (GAP) over the years. The annual rise in mustard yield attained was greatly in Rewari (2.19%) district and the lowermost in Mahendergarh (1.28%) district during around the last 40 years. The decline in mustard acreage was reported in Hisar and Sirsa districts as mustard area shifted towards wheat owing to increased accessibility of irrigation water. The credible reasons for the increase in mustard production as area diverted from less profitable crops like chickpea and barley to mustard, the evolution of high yielding varieties, ample area coverage micro-irrigation system (sprinkler irrigation), increased use of balanced fertilization, timely planting, adoption of improved agronomic practices.

The value of CV and CV_t computed for area, production and yield of mustard designated greater variation in area (27.67%) in Sirsa district while large variation in production (31.96%) and yield (25.11%) in Hisar district, Mishra *et al.* (2015). The reliable reasons for variation in both districts owing to frequent shifting of area between mustard and wheat depending upon precipitation, picking of cotton crop, cultivation on poor fertility land, late planting and extremely low temperature during crop season. The variation in yield and production of mustard in all districts occurred due to area coverage, frost, late planting, longer low temperature during crop season, poor germination, weed infestation etc.

Table 7: Sustainability analysis of gram in selected districts (1980-2018)

SI	Bhiwani	Hisar	Sirsa	Mahendergarh
Pal and Sahu 2007	2	4	1	3
ICARDA 1994	1	4	2	3
Vishwajit *et al.* 2018	2	4	1	3

Table 8: Sustainability analysis of cotton in selected districts (1980-2018):

SI	Bhiwani	Hisar	Sirsa	Jind	Fatehabad
Pal and Sahu 2007	2	3	4	1	5
ICARDA 1994	2	3	4	1	5
Vishwajit *et al.* 2018	2	3	4	1	5

Table 9: Sustainability analysis of mustard in selected districts (1980-2018)

SI	Bhiwani	Hisar	Sirsa	Mahender-garh	Rewari
Pal and Sahu 2007	1	4	2	3	5
ICARDA 1994	1	5	3	2	4
Vishwajit *et al.* 2018	1	4	2	3	5

Sustainability of chickpea production

The sustainability of chickpea production depends upon variability in acreage and yield level, which is ultimately influenced by the adoption level of improved farm practices, improvement in infrastructures like irrigation and market agro-processing, product demand in domestic and international markets. Based on various techniques as employed by Pal and Sahu (2007), ICARDA (1994), and Viswajit (2018), Sirsa district indicated the highest sustainability of chickpea cultivation among the identified districts as adoption of improved cultivars, arrangement of water for protected irrigations, cultivation confined to reasonable good fertility land.

Sustainability of cotton production

The sustainability of cotton production is influenced by acreage and yield variability level, which is ultimately prejudiced by adoption level of better farm practices, use of Bt-cotton seed, improvement in infrastructures like irrigation and market, cotton lint demand in domestic and global markets. Based on various techniques as evolved by Pal and Sahu (2007), ICARDA (1994), and Viswajit *et al.* (2018), Jind district indicated the highest sustainability of cotton cultivation followed by Bhiwani, Hisar, Sirsa, and Fatehabad. The the sustainability of cotton yield in Jind and Bhiwani districts as cotton was least affected by biotic stresses.

Sustainability of mustard production

Based on various techniques employed for sustainability of crop yield by Pal and Sahu (2007), ICARDA (1994), and Viswajit *et al.* (2018), Bhiwani district indicated the highest sustainability of mustard cultivation trailed by Sirsa, Mahendergarh, Hisar and Rewari districts. The notable reasons for the sustainability of mustard yield in the Bhiwani district are continuous cultivation of large areas, expanded sprinkler irrigation coverage, regular supply of electricity, increased use of nutrients and quality seeds, adoption of better culture practices for weed management, timely planting, less water requirement, and its profitability over pulses etc.

CONCLUSION

The results reveal that chickpea indicated a negative growth rate for area and production in all the selected districts during the study period (1980-2018) A large area under chickpea was diverted towards other crops in Sirsa district. Cotton and mustard had shown a positive growth rate for production in all selected districts except Hisar for cotton. Bhiwani district had indicated the annual

highest growth rate in area and production of both cotton and mustard. Yields of cotton and mustard exhibited an increasing trend in all the selected districts. Area under chickpea had a very drastic decline in all the selected districts causing sharp drop in production, but yield revealed some increment except Bhiwani. Chickpea, cotton, and mustard yields were found with highest growth rates in Sirsa, Jind, and Rewari. The area and production variability had been significantly found in the case of chickpea in all the districts, Cuddy and Della (1978). Area variability was found maximum in Hisar, Bhiwani, and Sirsa for chickpea, cotton, and mustard. Production had the highest variability in Hisar for chickpea and mustard, whereas in the Bhiwani district, production variability in cotton was maximum. Hisar district had indicated maximum yield variability in chickpea and mustard while Jind for cotton. As the study reveals that all the selected crops were found unstable in most of the districts, but if we tried to find out yield sustainability among the districts, it was observed that Sirsa, Jind, and Bhiwani have the highest sustainability for chickpea, cotton, and mustard yield respectively Pal and Sahu (2007). The area and production of cotton indicated ups and down trend due to the incidence of biotic stresses and partial drought conditions. The area udder chickpea crop declined over the years due to replacement by wheat and mustard because slow fit profitability. Further, the area and production of mustard also indicate ups and downs in the trend due to weather variability and erratic rainfall.

The yield sustainability of crops like chickpea, cotton, and mustard largely depends on the use of quality and improved seed, availability of irrigation water, adoption of improved production and protection technologies, resulting in higher productivity. The better realization of the market price of produce, agro-processing and value addition, demand in domestic and international markets also favor the sustainability of cultivation of these crops in the state.

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